Searching for the Optimum Conditions of NLC-Sunscreen Formulae by Using Taguchi's Method

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The present study focuses on searching for the best sunscreen formula with PEG-containing nanostructured lipid carriers (NLC) used as ultraviolet (UV) protector enhancers. The PEG-containing NLC sunscreen formula was produced by hot high pressure homogenization technique in a lab-scale machine. In here, three oils (black currant, Miglyol® 812, Echium lycopsis), three waxes (Canuba, Compritol 888 ATO, and Bees), PEG, decyl glucoside, pentylene glycol and actives (ethylhexylmethoxycinnamate, oxybenzone, avobenzone) were used. A total of nine runs were carried out. The significant parameters are particle size, UV spectra, zeta potential, crystallinity index (CI) and rheological properties. The effect of process parameters on the properties of sunscreen formula was explored and used Taguchi's method to find the best formula with the aid of S/N ratio.

Evidences showed that all zeta-potential measurements obtained in this study were higher than 30mv, indicating that the stability of sunscreen formula as shown in Fig. 1. The particle sizes were found to be in the range of 115-507nm, depending on the storage time and temperature as shown in Fig. 2. It was found that SU9 had a lowest size for various conditions. The size range was observed between 115 and 150nm. From viscoelastic dynamic analysis, G' is always higher than G'' indicating that the PEG-containing NLC sunscreen formula exhibits colloid state. Fig. 3 is an example of rheology of NLC for No. SU 9. However, G' and G'' were quite different from run to run depending on the formula.

In addition, the absorption peak of UV spectrum was around 300nm wavelength, while the spectrum shows that the oil contained had a significant effect on the absorbance. The absorption spectrums for nine runs were shown in Fig. 4. It was found that SU9 had a highest absorption spectrum. Practically, CI and UV spectrum are more significant as compared with size and zata potential. Therefore, we used Taguchi's analysis regarding CI and UV here. According to CI, the importance sequences of parameters were Canuba wax ＞Beewax＞ Compritol 888 ATO for wax and Black currant oil ＞Echium oil ＞Miglyol® 812 for oil, respectively. On the other hand, from the viewpoint of UV, the importance sequences of parameters were Beewax＞Canuba wax ＞ Compritol 888 ATO for wax and Miglyol® 812 ＞ Echium oil ＞ Black currant oil for oil, respectively. However, we obtained the following important conclusions:

1. The optimum prescription of NLC-sunscreen was:

Parameters	CI	VU
Best prescription	SU2	SU9
Component	Canuba wax Black currant oil	Beewax Miglyol® 812

2.The zeta-potentials for NLC-sunscreens obtained for 60-days storage are in the range of -45.8 to -36.6mv showing the stability of NLC-sunscreens.

3. From the purpose of practical, CI and UV are more significant. Therefore, SU2 and SU9 are more effective prescriptions for CI and UV, respectively.

4.However, from size and zeta potential, the SU9 is the best one.

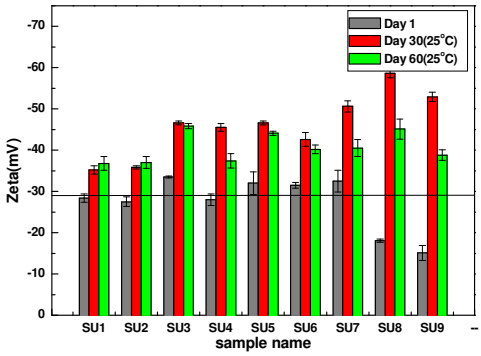

Fig. 1 Zeta-potentials for various NLC prescriptions at different storage times

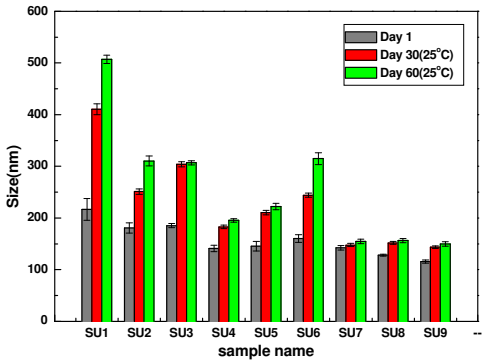

Fig. 2 Particle sizes of NLCs for various prescriptions at different storage times

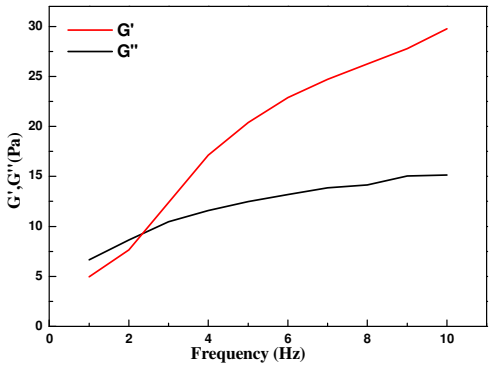

Fig. 3 Viscoelastic behavior of NLC for SU9 showing dynamic analysis result.

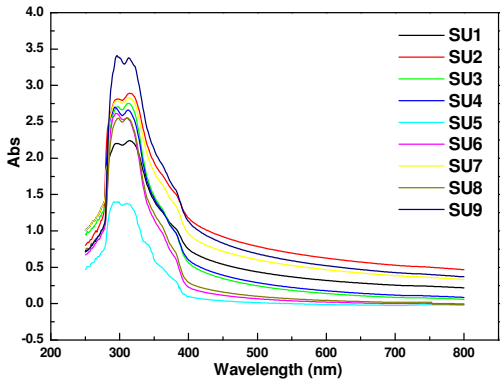

Fig. 4 VU spectrums for various NLCs showing the absorption strength

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